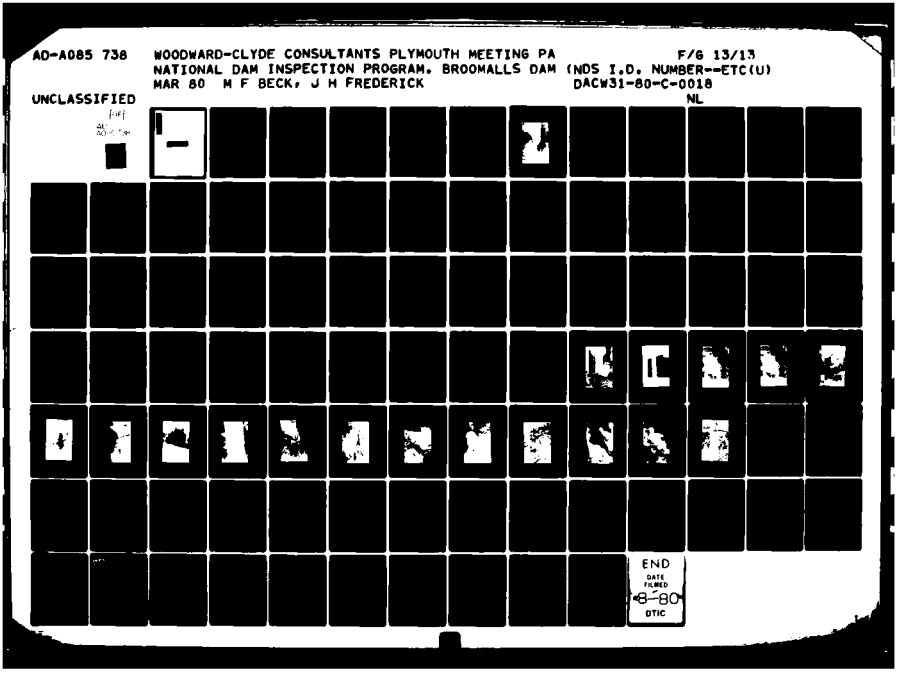
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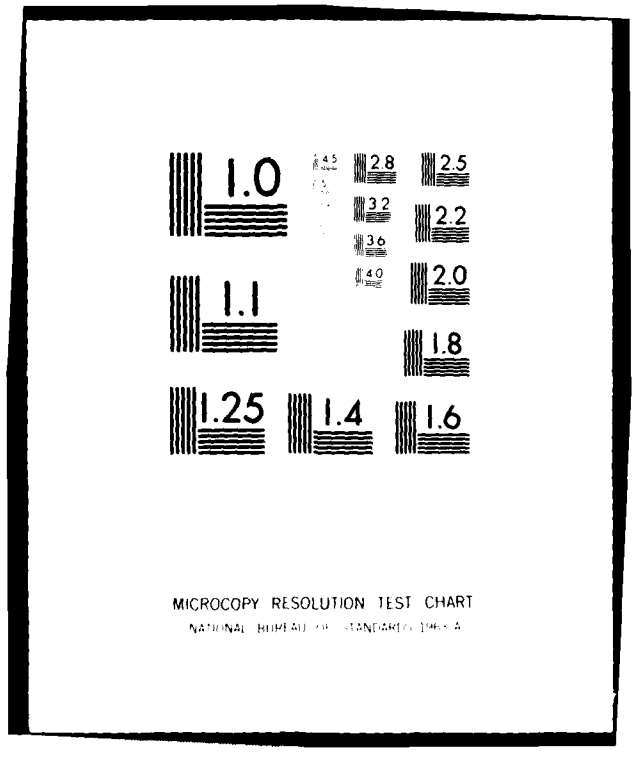
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WOODWARD-CLYDE CONSULTANTS

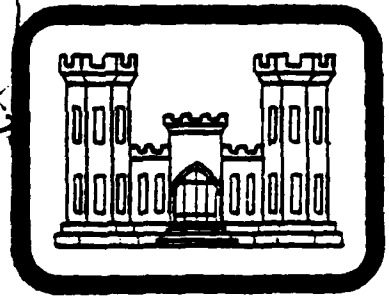
DACW31-80-C-0018

DELAWARE RIVER BASIN

TRIBUTARY TO RIDLEY CREEK
BROOMALLS DAM
DELAWARE COUNTY, PENNSYLVANIA

(NDS I.D. NO. PA 00349,
DER I.D. NO. 23-9), Delaware River Basin
Tributary to Ridley Creek, Delaware County,
Pennsylvania.

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



Prepared by:

WOODWARD-CLYDE CONSULTANTS
5120 Butler Pike
Plymouth Meeting, Pennsylvania 19462

Submitted to:

DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

March 1980

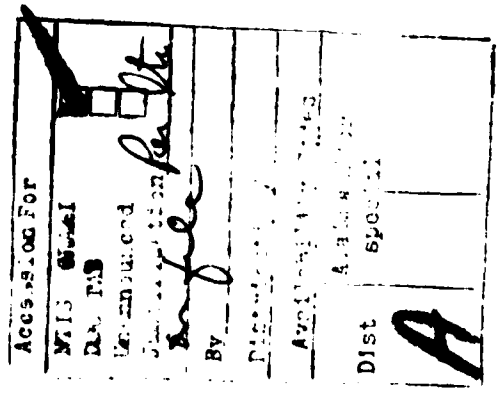
PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams for Phase I Investigations. Copies of these guidelines may be obtained from the Office of the Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to expeditiously identify those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigations, testing and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify the need for more detailed studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected, and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.



PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

Name of Dam:	Broomalls Dam
County Located:	Delaware County
State Located:	Pennsylvania
Stream:	Unnamed tributary to Ridley Creek
Coordinates:	Latitude 39° 53.3' Longitude 75° 23.8'
Date of Inspection:	November 12, 1979

Broomalls Dam is owned by the Media Swimming and Rowing Club. The dam is currently used for recreation.

Visual inspection indicates that the dam and spillway structures of Broomalls Dam are in poor condition. In 1970, the original spillway capacity was supplemented by the installation of three 27 inch by 43 inch corrugated metal pipe arches, with an entrance invert about five inches above the spillway and discharging at the downstream toe. The November inspection disclosed that surface erosion above the pipes had occurred, probably as a result of surface runoff over the downstream parapet wall. Some erosion below the culvert outlets was evident. Subsequent inspection in February 1980, disclosed considerable erosion and apparent piping at the downstream end of the culverts. One culvert was fill with ice at its outlet and had a column of ice reaching from the outlet to the ground surface. Ice was also visible at the junction of the culverts and embankment. There appears to be a small, constant, undetermined source of water for ice formation. At the request of local Department of Environmental Resources officials, the reservoir has been lowered about 2.5 feet through the upper drain. As a result of the rapid deterioration in the condition of the dam since November, the dam is considered to be in an "unsafe, nonemergency" condition.

In accordance with criteria established by Federal (OCE) Guidelines, the spillway design flood for this "Small" size dam and "High" hazard classification is one-half to the full Probable Maximum Flood (PMF). As the height of the dam is near the lower limit for small size dams, and the total capacity is less than the lower limit, the selected spillway design flood is 0.5 PMF. The hydrologic and hydraulic computations presented in Appendix D indicate that the structure will pass 0.25 PMF without overtopping. It is assessed that less than 0.1 PMF could cause failure by piping along the CMP culverts and an 0.4 PMF event would cause failure by overtopping. Failure would significantly increase

the potential for excessive property damage and loss of life in the downstream damage center, 2,000 feet below the dam. Therefore, the spillway system of this "High" hazard classification structure is considered to be "Seriously Inadequate".

It is recommended that the following measures be undertaken immediately as emergency measures. All work should be done under the supervision of a registered professional engineer experienced in the design and construction of dams.

1. The source of water forming ice around the pipe arches should be determined and the necessary remedial measures undertaken.

2. The reservoir should be maintained at its present level, about 2.5 feet below normal pool, until the necessary repairs are completed.

The following measures, presented in the order of priority, are also important and should be undertaken as soon as practical. All work should be done under the supervision of a registered professional engineer.

3. A detailed hydrologic/hydraulic study should be made and the spillway upgraded to meet current hydrologic/hydraulic criteria.

4. The corrugated metal culvert should be rehabilitated or replaced. Discharge from these culverts should be prevented from impinging on the downstream toe.

5. Deterioration of the spillway walls should be repaired.

6. The condition of the downstream parapet wall should be evaluated in detail and the possible need for a buttress fill downstream of the wall evaluated.

7. Surface runoff should be prevented from flowing over the downstream parapet wall and eroding the downstream face.

8. The large trees on both the upstream and downstream slopes of the embankment should be removed. However, the long-term stability of the slopes should be evaluated in light of decaying root systems.

9. Existing erosion on the downstream slope should be repaired. Protection of the downstream embankment in the vicinity of the storm sewer outlet is required.

Because of the location of the dam and the potential for heavy property damage and possible loss of life in the event of failure, a formal procedure of observation and warning during periods of high precipitation should be developed and implemented. This procedure should include a method of warning downstream residents at Ridley Creek Road that high flows are expected and provisions for evacuating these people in the event of an emergency. An operation and maintenance procedure should also be developed to insure that all pertinent items are carefully inspected on a regular basis and maintained in the best possible condition.

Mary F. Beck 3/19/80

Mary F. Beck, P.E. Date
Pennsylvania Registration [illegible]-E
Woodward-Clyde Consultants

3/19/80

John H. Frederick, Jr., P.E. Date
Maryland Registration 7301
Woodward-Clyde Consultants

APPROVED BY:

25 APR 80

JAMES W. PECK Date
Colonel, Corps of Engineers
District Engineer

OVERVIEW
BROOMALLS LAKE DAM, DELAWARE COUNTY, PENNSYLVANIA

TABLE OF CONTENTS

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
BROOMALLS DAM
NATIONAL ID NO. PA 00349
DER NO. 23-9

SECTION 1
PROJECT INFORMATION

1.1 General.

a. Authority. The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.

b. Purpose. The purpose of the inspection is to determine if the dam constitutes a hazard to human life or property.

1.2 Description of Project.

a. Dam and Appurtenances. Broomalls Dam is an earth and rock dam about 29 feet high and about 500 feet long. Very limited data exists regarding the physical features of the dam. The upstream face of the dam above the water level is a masonry wall. As shown in Photograph 6, a walkway has been constructed slightly above normal pool elevation, with an elevated bridge crossing the approach to the spillway. A two lane paved road, Third Street, crosses the dam breast. There is a downstream masonry parapet wall which does not extend the full height of the dam, but is founded in the downstream slope. Both walls have an opening over the spillway to allow the discharge of runoff from the road. Below the downstream parapet wall, the downstream slope is about 1.5H:1V to 1.75H:1V. The minimum elevation of the roadway over the dam is approximately 191.9 feet, six feet above the spillway entrance. The parapet walls are about 17 inches above the edge of the pavement, although the downstream wall has a minimum height of about six inches above the pavement.

The upstream side of the box culvert spillway is shown in Photograph 1. The spillway entrance is about nine feet seven inches wide by five feet three inches high, with an invert at approximately 185.9 feet. The box culvert itself is eight feet wide and about six feet high to the underside of beams supporting the roadway. Discharge flows under Third Street and falls freely about 19 feet, as shown in Photograph

4. Three corrugated metal pipe arches, 43 inches wide by 27 inches high "squashed" sections, were installed in about 1970. The entrance invert of the three CPM culverts is about five inches above the spillway box culvert invert. Any flow through the corrugated metal pipe arches would discharge directly onto the downstream toe of the dam. A walkway has been constructed slightly above normal pool level along the upstream wall. A wooden bridge crosses the spillway entrance, as shown in Photograph 6.

There are two drain pipes which outlet under the spillway. A ten inch line, whose invert is about 2.5 feet below the invert of the box culvert, discharges below the free overfall. A second pipe, whose outlet can be seen in Photograph 4, is near the base of the dam. This pipe is reported to be 42 inches in diameter, but visually appears to be about six inches in diameter. It is believed that the outlet of the 42 inch pipe has been enclosed in a masonry box with a six inch outlet. The inlet to the lower drain is likely buried under sediment and has not been operable for about 65 years.

Plan and section views of the dam are included as Plates 2 and 3, Appendix E.

b. Location. The dam is located across an unnamed tributary to Ridley Creek in Media Borough, Delaware County, Pennsylvania. The dam site is located just west of the intersection of West Third Street and South Orange Street, Media. The dam site and reservoir are located on the USGS Quadrangle map entitled "Media, Pennsylvania", at coordinates N 39° 53.3' W 75° 23.8'. A regional location plan of Broomalls Dam and reservoir is enclosed as Plate 1, Appendix E.

c. Size Classification. The dam is classified as a "Small" size dam by virtue of its 29 foot height.

d. Hazard Classification. A "High" hazard classification is assigned consistent with the dam's location within an urban area, and the potential to cause extensive property damage and loss of life downstream along the creek.

e. Ownership. The dam is owned by the Media Swimming and Rowing Club. Correspondence should be addressed to Mr. Frank Fields, 339 West Fourth Street, Media, Pennsylvania 19063. A borough road, Third Street, crosses the dam crest, and a county park is immediately downstream of the dam and, as shown on Plate 1, Appendix E, includes a portion of the downstream slope. Media Borough Secretary is Mr. James J. Loughran, Post Office Box A, Media, Pennsylvania 19063, and

the chairman of Delaware County Commissioners is Mr. Charles Keeler, Delaware County Court House, Media, Pennsylvania 19063.

f. Purpose of Dam. The dam is currently used for recreation.

g. Design and Construction History. The dam was first inspected in 1915 by the Water Supply Commission, forerunner of the Pennsylvania Department of Environmental Resources (DER). The dam was reported to have been constructed in the spring of 1883 or 1884, by Mr. John M. Broomall for ice harvesting purposes, an ice house having been erected on the shore of the pool. The structure was described as an earth and rock embankment spanning a depression between the hills, along whose bases the creek flows. The embankment crest length was approximately 250 feet between the points where the natural ground surface is reached and had a width of 20 feet at its crest. The upstream slope was noted to vary, averaging between 1.5H:1V and 2H:1V. The downstream face, with a slope of 1.5H:1V, was covered with loose rock which appeared to have been dumped from the crest. The reported method of construction was that material was excavated from the hillsides on each side of the stream, being hauled by carts and dumped upon the natural ground surface. No endeavor to cut off seepage along the base or through any portions of the embankment was stated to have been made. The outlet pipe was rolled into place and earth dumped on it. The mortared masonry spillway was of the same configuration as presently exists. The 42 inch lower pond drain conduit was controlled at the upstream end. A valve stem with supports projecting above the surface of the pool could be seen about 30 feet from the spillway entrance. A timber gate was stated to control the entrance to the waste pipe. The gate stem was reported broken and the pool could not be drained. There is no subsequent report that the pond drain control has ever been operable. At that time, the embankment crest was reported to be uneven and covered with brush, and small trees were growing on the downstream embankment. The state directed the Owner to make improvements and repairs to the dam. As a borough road crossed the breast of the dam, the Owner contended that the borough had the responsibility for maintenance of the dam. The borough countered with the contention that the borough was only interested in the roadway and it was the Owner's responsibility to maintain the dam.

In 1917, the ownership of the dam changed hands. The new Owner did some of the repair work and Media Borough agreed to do some other repair work. In 1919, the ownership was transferred to the current owner, the Media Rowing and Swimming Club, which agreed to complete the remainder of the

required improvements. A 1920 inspection of the dam disclosed that previously requested repair work had been performed.

In 1927, the state first noticed the outlet of a storm sewer at the downstream left abutment of the dam. Erosion had started at the toe. Correspondence was exchanged between the state and the Owner concerning erosion of the dam toe. In 1931, a state engineer inspected the dam and found the erosion resulting from the storm drain to be filled in. The engineer concluded that the storm discharge would have no effect on the dam as the slopes near the stream were laid up as rough stone walls. Highway runoff also discharged over the face of the dam, although it was considered to be too small to cause immediate serious erosion.

A 1937 progress report in DER files indicates that the Media Swimming and Rowing Club had donated a section of land downstream from the dam to Media Borough and that the club agreed to maintain the upstream side of the dam while the borough was to maintain the downstream side of the dam. New drainage facilities were being installed on the roadway to carry runoff to the spillway. Also, a storm sewer outlet with stone masonry head walls and retaining walls was under construction about 30 feet downstream from the left end of the dam. The right wing wall of this culvert was to be extended along the downstream face of the dam about 20 feet.

A 1964 state inspection indicated that the roadway was newly constructed. In 1964, the Owner was directed to remove the trees and brush growing on the downstream face of the dam. Beyond the Water Resources Inventory form, there are no further records in the state files.

It is reported by the Owner's representative that the present upstream wall, paid for by the borough, was installed in 1957 or 1958, widening the embankment crest to the present 35 feet. About 1970, the three corrugated metal auxiliary spillway conduits or culverts were installed by the open-cut method. In the early fall of 1979, the roadway above the corrugated metal culvert upstream and downstream was repaired.

h. Normal Operating Procedures. Reservoir flows are normally discharged through the masonry culvert under the bridge. The reservoir can be lowered about 2.5 feet by removing the wooden cover from the upper drair a ten inch cast iron pipe. The lower drain has been inop.rable since before 1915.

1.3 Pertinent Data.

A summary of pertinent data for Broomalls Dam is presented as follows.

a.	Drainage Area (square miles)	0.54
b.	Discharge at Dam Site (cfs)	
	Maximum Known Flood at Dam Site	400 (estimated)
	At Top of Dam	540
c.	Elevation (feet above MSL)	
	Top of Dam	191.9
	Corrugated Metal Culverts Inlet	186.3
	Spillway Weir (1)	185.9
	Pond Drain Inlet	183.4±
	Maximum Reported Water Surface	190.8
	Downstream Toe of Dam	162.9
d.	Reservoir (feet)	
	Length at Normal Pool	500
e.	Storage (acre-feet)	
	To Spillway (normal pool)	18
	To Top of Dam	41
f.	Reservoir Surface Area (acres)	
	Normal Pool	2.5
	Top of Dam	4+
g.	Dam Data	
	Type	Earth and rock with masonry upstream and downstream walls
	Volume	20,000 cu yd (est)
	Length	500 feet
	Maximum Height	29 feet
	Top Width	35 feet
	Side Slopes	
	Upstream	Vertical masonry wall (above water level)
	Downstream	1.5H:1V to 1.75H:1V below vertical masonry wall
	Cutoff	None
	Grout Curtain	None

(1) Elevation supplied by Owner's representative. All other elevations are relative.

h. Spillways

Box Culvert	
Type	Masonry w/free overfall
Reservoir Drain	10" diameter pipe
Elevations (feet)	
Weir	185.9
Pond Drain	183.4±
Corrugated Metal Pipe Arches	
Number	Three
Size	27" x 43"
Inlet Invert	186.3
Outlet Invert	Unknown; see Photo 4

SECTION 2
ENGINEERING DATA

2.1 Design.

a. Data Available. The only data available for review are the state inspection reports, correspondence, memos and photographs contained in the Department of Environmental Resources (DER) files. These reports contain a limited description of the physical features of the dam. The only record of any engineering analysis being performed for this dam is an estimation of the spillway capacity performed as a part of the original 1915 state inspection of the dam.

b. Design Features. The principal design features of Broomalls Dam are illustrated on the plan and cross-section enclosed in Appendix E. Data for these sections were obtained from the Owner and supplemented by field investigations in November 1979.

2.2 Construction.

Beyond the limited information given in Section 1.2, there are no data available concerning the construction history of this dam and reservoir.

2.3 Operational Data.

There are no operational records maintained. There are no minimum flow requirements downstream of this dam. The reservoir may be lowered about 2.5 feet by removing the wood cover from the upstream end of the ten inch drain pipe. The control to the lower pipe reportedly has not been operable since before 1915.

2.4 Evaluation.

a. Availability. Information presented herein was obtained from records located in DER files in Harrisburg, Pennsylvania, and from conversations with the Owner's representative.

b. Adequacy. The available data included in the state files and presented in this report are not adequate to evaluate the engineering aspects of the dam and appurtenant structures.

c. Validity. There is no reason to question the validity of the limited available data.

SECTION 3
VISUAL INSPECTION

3.1 Findings.

a. General. Observations and comments of the field inspection team are contained in the checklist enclosed herein as Appendix A, and are summarized and evaluated in the following subsections. In general, the appearance of the facility in November 1979 and February 1980, indicates that the dam is in very poor condition. A plan and cross-section of the dam, based on the Owner's plan and supplemented by field observations, are shown in Plates 2 and 3, Appendix E.

b. Dam. During the visual inspection, there were no indications of distortion in alignment or grade that would be indicative of deep seated movement of the embankment or foundation. The vertical alignment of the dam was checked and elevations are shown on sheet 5b, Appendix A. No discernible horizontal displacement of the upstream parapet wall was noted. The upstream wall appears to be in good condition, although there is some deterioration of the mortared joints and at least three stone blocks are missing. The crest of the dam is Third Street and currently appears in good condition, with two areas that were recently patched (in September 1979) shown in Photograph 7. Photograph 7 also shows the downstream horizontal displacement of the downstream parapet wall. The downstream parapet wall and slope are considered to be in poor condition. The wall itself gives evidence of being rotated outward, in addition to loss of support above the corrugated metal culverts. Erosion has also exposed the bottom of the wall in the area to the right of the spillway. There are large trees growing on the downstream embankment. The left downstream parapet wall has cracking between the wall and the roadway pavement in spite of recent repairs. The whole downstream slope has eroded, reportedly as a result of heavy surface runoff from Third Street flowing over the downstream wall. Cracking was observed in the downstream wall adjacent to the spillway. Erosion has occurred at the junction of the embankment and spillway and at the downstream junction of the embankment and left abutment. The large storm sewer outletting there has aggravated that erosion. The right storm sewer retaining wall has collapsed completely, leaving a vertical cut in the downstream embankment.

Seepage was noted about 30 and 60 feet to the right of the spillway. Near the right end of the dam, there are five seeps which come together to form a stream, which joins the main spillway discharge about 300 feet below the dam. Along

the downstream toe of the embankment to the right of the spillway are marshy areas which can be attributed to seepage under or through the dam embankment. No specific seepage was noted through the embankment to the left of the spillway; however, a good deal of rock is in the area and could mask any seepage. In February, the water level in the reservoir and downstream channel was lower and two seepage areas to the left of the channel were noted as shown on sheet 5a, Appendix A. Both seepage areas are rust stained.

c. Appurtenant Structures.

1. Spillway. The mortared stone entrance to the spillway and the spillway chute under the highway appear to be in poor condition. In March, after the reservoir had been lowered, two shallow cracks were noted in the chute floor. One crack, about seven feet from the entrance, is about 2.5 feet long and six inches wide at its widest point. The second crack is near the downstream end of the culvert. A 12 inch water pipe, enclosed in an 18 inch jacket, crosses the spillway under the highway, as shown in Photograph 2. In November, the spillway walls downstream of the dam appeared to be in fair condition, but with some deterioration, as shown on Photograph 14. In February, a two foot by four foot by six foot section had fallen out of the left spillway wall. The whole cement face appeared to be buckling. Water could be seen dripping from stone inside of the hole. A smaller section, about two feet by one foot by one foot had fallen out of the right spillway wall about four feet above the floor. Therefore, the spillway is considered to be in poor condition.

Three corrugated metal pipe arches have been installed under the roadway. The invert of these is about five inches above the invert of the main spillway. As shown in Photographs 4 and 12, the discharge end of the middle culvert has lost supporting soil and settled. The culvert buckled at the point where it bent. Reportedly, this has been a result of surface runoff from Third Street, flowing over the downstream parapet wall and down the embankment face. Water flowing through the culverts would discharge onto the downstream toe of the embankment, causing erosion and further settlement of the discharge ends of the culverts. In February 1980, the culvert next to the spillway was full of ice at its outlet and had a column of ice between the culvert outlet and embankment toe. There was no supporting soil for at least 16 feet behind the outlet. Ice was visible where the culvert entered the soil. The middle culvert has pulled apart at a joint and is held together by a band. Evidence of possible piping was visible under both culverts.

2. Outlet Works. There are two drain conduits outletting through the spillway of this dam. The upper drain, a 10 inch cast iron pipe, is about 2.5 feet below the spillway. Flow through the upper drain pipe is prevented by a wooden cover held against the intake end of the pipe by the water pressure. The lower drain is about 19 feet below the spillway and reportedly is a 3.5 foot diameter riveted seam conduit. The outlet of this pipe has apparently been enclosed in a masonry structure with an approximately six inch opening. The inlet to the lower pipe is reportedly buried under sediment and has not been operable for about 60 years. Reportedly, the upper drain will lower the reservoir about 2.5 feet in a day and a half.

d. Reservoir. The reservoir slopes are moderate to steep and vegetated to the water's edge with grass or trees. A considerable amount of sediment has accumulated within the reservoir, and the upper end has been filled in to accommodate construction of swimming pools. Sediment accumulation in the reservoir has reportedly been measured as eight feet deep in front of the boat house, at a point where the water is currently eight feet deep. The normal and maximum reservoir capacities reported in Section 1.3 have not accounted for the sediment volume. In the event of failure, a considerable amount of sediment would flow down the valley also.

e. Downstream Channel. For about 2,000 feet below the dam, the channel flows through Glen Providence Park, a county park. The channel is about 8 to 14 feet wide with 1H:1V side slopes. The channel is fairly open, but with some logs across the top. There is considerable underbrush to the right of the channel in the flood plain. Work has recently been done in the park; the stream has been diverted to enter the upper end of the pond shown on Plate 1. The maximum height of the earth embankment retaining the pond is estimated to be ten feet. The surface area of the pond is about 1.5 acres. A ten inch PVC pipe and an 18 inch CMP are laid through the embankment. Additional uncompacted fill has been placed on the embankment. A small breach has already formed on the east side of the embankment at about the third point from the upper end. It is assessed that the embankment will fail in the event of a large storm.

About 2,000 feet below the dam are three houses that would be damaged in the event of failure. These houses are reported to have water in the basements during periods of high runoff. One house is below the level of Ridley Creek Road, which forms an obstruction across the flood plain. At about 300 feet downstream of Ridley Creek Road, the stream flows under Baltimore Pike and enters Ridley Creek. Thus, in the event of failure, excessive property damage is likely and the

potential exists for loss of life, justifying a "High" hazard classification.

3.2 Evaluation.

Inspection of the dam and appurtenant facilities disclosed no evidence of apparent past or present deep seated movement that would indicate an existing instability of the dam or spillway system. Seepage has been noted since the original 1915 state inspection and appears not to have increased in amount. Thus, the seepage at the toe is not considered significant. The downstream slope has been subjected to erosion and possible piping, which should be halted and repaired. The erosion has been caused by surface runoff over the parapet wall and also probably by discharge through the corrugated metal conduits.

Ice in the right corrugated metal culvert, and visible at the junction of the culverts and embankment, indicates a constant source of water. Possible sources of water are: a small leak in the waterline under the roadway, groundwater seepage from under the roadway exiting from the culvert trench backfill, surface runoff entering cracks in the pavement and between the pavement and parapet wall (although pavement cracks were repaired in the fall of 1979), or seepage through the dam from the reservoir (although seepage was not noted exiting the embankment above the downstream toe). Ice inside the culverts indicate the culverts are not watertight and, if the culverts carry discharge from the reservoir, water would enter the embankment, contributing to piping. Thus, the source of the water should be determined and the necessary remedial measures undertaken.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedures.

Operation of the dam does not require a dam tender. Under normal conditions, flow discharges through the spillway. An increase of five inches in the reservoir level will cause the corrugated metal culverts to carry water. The entrance to the spillway is at elevation 185.9.

4.2 Maintenance of the Dam.

A 1937 state progress report indicates an agreement between the Owner and the Borough of Media that the Owner is responsible for maintenance of the upstream slope of the dam; and the borough, in return for a section of land donated by the Owner, is responsible for maintenance of the downstream slope. However, as the downstream Glen Providence Park is a county park, it is unknown who is responsible for the dam. According to the Owner's representative, there is no routine maintenance performed on the dam. The only maintenance provided by the Owner is the removal of debris from the reservoir area.

4.3 Maintenance of Operating Facilities.

No routine maintenance of the operating facilities is performed.

4.4 Warning Systems In Effect.

There is no written warning system in effect. The Owner's representative indicated that in the event a problem developed, he would notify the local police.

4.5 Evaluation.

It is judged that the current operating procedure, which does not require a dam tender, is a realistic means of operating the relatively simple control facilities of Broomalls Dam. If the previous agreement between the borough and the Owner is still in effect as to the maintenance of the dam, then the borough should provide maintenance to the downstream slope.

In conclusion, it is noted that formal operational, maintenance and warning procedures should be developed and implemented as soon as practical. It should be noted that these procedures should include an inspection checklist, which would include a listing of items to be checked during each inspection and repaired as necessary to insure proper performance of the structure.

SECTION 5
HYDROLOGY/HYDRAULICS

5.1 Evaluation of Features.

a. Design Data. There are no original design data available for this dam. An evaluation of the spillway capacity, made in 1915, indicates that the discharge capacity was estimated to exceed 400 cfs, and was considered adequate.

The watershed is about one mile long and averages about two-thirds of a mile wide, having a total drainage area of 0.54 square mile. Elevations within the watershed range from about 300 feet in the upper reaches to about 185 feet at normal pool elevation. The watershed is almost completely developed to its full extent.

In accordance with criteria established by Federal (OCE) Guidelines, the spillway design flood for this "Small" size dam and "High" hazard classification is one-half to the full Probable Maximum Flood (PMF). As the height of the dam is near the lower limit for small size dams, and the total capacity is less than the lower limit, the selected spillway design flood is 0.5 PMF.

b. Experience Data. There are no records of reservoir levels or rainfall kept for this dam. The maximum known water level is reported to be about 4.9 feet above normal pool, or 190.8 feet, which occurred during a storm when the spillway was noted to be blocked by tree limbs.

c. Visual Observations. On the date of the inspection, the only condition observed that might indicate a possible reduction in spillway capacity is that debris is likely to accumulate on the trashrack to the three corrugated metal culverts. Observations regarding the condition of the downstream channel, spillway and reservoir are located in Appendix A, and are discussed in greater detail in Section 3. Recommendations are made in Section 7.

d. Overtopping Potential. The overtopping potential of this dam was estimated using the HEC-1, Dam Safety Version, computer program. A brief description of the program is included in Appendix D.

Calculations indicate that the combined spillway and culvert discharge capacity is about 540 cfs when the water is at the minimum top of road elevation, neglecting the presence of the upstream parapet wall. The parapet wall is

about 17 inches above the roadway, except there is no parapet wall over the box culvert. Thus, the wall has been neglected in the overtopping analysis. The HEC-1 program computed the peak inflow from 0.5 PMF to be 1,260 cfs. The spillway can pass about 25 percent of the PMF without overtopping the dam.

e. Spillway Adequacy. A spillway that will not pass 0.5 PMF without overtopping the dam is rated as "Seriously Inadequate", provided two other conditions are present. One is failure of the dam by overtopping. Broomalls Dam is assumed capable of withstanding overtopping of up to one foot before failing as a result of overtopping. As estimated by the HEC-1 computer program, the dam will fail at events approaching 0.4 PMF. Based on the appearance of the dam in February 1980, it is conservatively estimated that the dam could fail by piping along the outside of the CMP culverts if the reservoir level approaches the top of the culvert or elevation 188.6. The dam is then estimated to fail during an event smaller than 0.1 PMF.

The second requirement for a "Seriously Inadequate" spillway is that downstream damage resulting from failure is significantly greater than that which would occur from high flows just before failure. This criteria is also met (see the following paragraph); therefore, the spillway is rated as "Seriously Inadequate".

f. Downstream Conditions. It is assessed that the major downstream hazard center is located approximately 2,000 feet below the dam, where three houses are built adjacent to the stream. Immediately downstream of the houses, the stream flows through a combination reinforced concrete and corrugated metal culvert under Ridley Creek Road, ranging in diameter from five feet to eight feet. The upstream invert is estimated to be at about elevation 107. The minimum elevation of Ridley Creek Road is about 119, slightly higher than the first floor elevation of the lowest house (118.8). The assumed failure criteria for existing conditions (February 1980) indicate the peak flow over Ridley Creek Road will increase nearly five times, from about 230 cfs to about 1,100 cfs for the 0.1 PMF event. The water level is expected to increase by more than one foot. As the 0.1 PMF event is not a large storm and Broomalls Dam has probably safely discharged that event in the past, downstream residents may not even consider the possibility of a dam failure. Failure of the dam by overtopping more than doubles the peak flow over Ridley Creek Road, from less than 1,000 cfs to more than 2,100 cfs, for the 0.4 PMF event. The water level is expected to increase by about one foot. Therefore, as failure would cause greater property damage and greater potential for loss of life than nonfailure during the same event, a "Seriously Inadequate" classification is justified.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability.

a. Visual Observations. Evidence of existing or pending embankment or spillway instability detected by visual observations would be that which would result from overtopping, from surface runoff over the downstream slope of the dam, or piping along the outside of the corrugated metal culverts. Considerable erosion and possibly piping had taken place under the corrugated metal culverts. One culvert is unsupported by soil for at least 16 feet from the outlet, and there is evidence of piping under two culverts. Ice within the right culvert indicates the culverts are not watertight, and reservoir flow through the culverts could enter the embankment and cause piping. Structural instability of the downstream spillway walls is evidenced by the deterioration of the walls during the winter of 1979-1980.

b. Design and Construction Data. Design drawings and stability analyses do not exist for this structure. Based on the dam's appearance, it is qualitatively assessed that the stability of the dam is presently not adequate. However, if the dam is returned to its original condition by repair of the erosion and apparent piping damage and if future damage is prevented, it is assessed that the stability would be adequate. Since the downstream parapet wall was not part of the original structure, and serves only to widen the roadway, the apparent movement and cracking would not affect the stability of the dam itself, although it may have an effect on the stability of the roadway.

c. Operating Records. There are no operational records for this structure.

d. Post-Construction Changes. Between 1917 and 1920, the dam was rehabilitated, including the extension of the upstream spillway walls. The 42 inch outlet pipe was enclosed in a masonry box with an approximately six inch diameter outlet, probably at about the same time. The crest of the dam was widened from 20 feet to 35 feet to accommodate a wider street. The widening was accomplished by constructing masonry parapet walls on the slopes. In 1970, the three corrugated metal culverts were added through the embankment.

e. Seismic Stability. The dam is located in Seismic Zone 1. Normally it can be considered that if a dam in this zone is stable under static loading conditions, it can be assumed safe for any expected earthquake conditions. As the stability of the dam is qualitatively assessed to be inadequate under present static loading conditions, it can reasonably be assumed to be inadequate under seismic loading conditions. However, if the dam is returned to its original condition, it is assessed that the dam would be stable under seismic loading conditions.

SECTION 7
ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment.

a. Evaluation. Visual inspection indicates that the dam and spillway structures of Broomalls Dam are in poor condition. The selected spillway design flood for this dam is 0.5 PMF. The hydrologic and hydraulic computations presented in Appendix D indicate that the structure will pass 0.25 PMF (Probable Maximum Flood) without overtopping. It is assessed that an event of less than 0.1 PMF could cause failure by piping along the CMP culverts and an 0.4 PMF event would cause failure by overtopping. Failure would significantly increase the potential for excessive property damage and loss of life in the downstream damage center, 2,000 feet below the dam. Therefore, the spillway system of this "Small" size dam with a "High" hazard classification is considered to be "Seriously Inadequate" and in an "unsafe, nonemergency" condition.

b. Adequacy of Information. The combined visual inspection, obvious performance history of this structure, and simplified calculations presented in Appendix D were sufficient to determine that a further detailed hydrologic and hydraulic analysis is required. The appearance of the dam in February 1980, indicated the dam is in urgent need of attention.

c. Urgency. It is recommended that the measures presented in Section 7.2 be implemented as specified.

7.2 Remedial Measures.

a. Facilities. It is recommended that the following measures be undertaken immediately. All work should be done under the supervision of a registered professional engineer experienced in the design and construction of dams.

1. The source of water forming ice around the pipe arches should be determined and the necessary remedial measures undertaken.

2. The reservoir should be maintained at its present level, about 2.5 feet below normal pool, until the necessary repairs are completed.

The following measures, presented in the order of priority, are also important and should be undertaken as soon as

practical. All work should be done under the supervision of a registered professional engineer.

3. A detailed hydrologic/hydraulic study should be made and the spillway upgraded to meet current hydrologic/hydraulic criteria.

4. The corrugated metal culvert should be rehabilitated or replaced. Discharge from these culverts should be prevented from impinging on the downstream toe.

5. Deterioration of the spillway walls should be repaired.

6. The condition of the downstream parapet wall should be evaluated in detail and the possible need for a buttress fill downstream of the wall evaluated.

7. Surface runoff should be prevented from flowing over the downstream parapet wall and eroding the downstream face.

8. The large trees on both the upstream and downstream slopes of the embankment should be removed. However, the long-term stability of the slopes should be evaluated in light of decaying root systems.

9. Existing erosion on the downstream slope should be repaired. Protection of the downstream embankment in the vicinity of the storm sewer outlet is required.

b. Operation and Maintenance Procedures. Because of the location of the dam and the potential for heavy property damage and possible loss of life in the event of failure, a formal procedure of observation and warning during periods of high precipitation should be developed and implemented. This procedure should include a method of warning downstream residents at Ridley Creek Road that high flows are expected and provisions for evacuating these people in the event of an emergency. An operation and maintenance procedure should also be developed to insure that all pertinent items are carefully inspected on a regular basis and maintained in the best possible condition.

APPENDIX

A

CHECK LIST
VISUAL INSPECTION
PHASE I

Name Dam *Broomalls Lake Dam* County *Delaware* State *Pennsylvania* National ID # *PA 00349*

Type of Dam *Earth and Rock* Hazard Category *High*

Date(s) Inspection *11/12/79* Weather *Partly cloudy* Temperature *50's*

Pool Elevation at Time of Inspection *186±* M.S.L. Tailwater at Time of Inspection *N/A* M.S.L.

Inspection Personnel:

Mary F. Beck (Hydrologist)
Arthur H. Dvinoff (Geotechnical/Civil)
Vincent McKeever (Hydrologist)
Raymond S. Lambert (Geologist)
John Frederick (Geotechnical/Civil)
10/30/79

Mary F. Beck Recorder

Remarks:

Mr. Frank Fields, representing Media Swimming and Rowing Club, was on site and provided assistance to the inspection team.

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE	*N/A*	
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	*N/A*	
DRAINS	*N/A*	
WATER PASSAGES	*N/A*	
FOUNDATION	*N/A*	

CONCRETE/MASONRY DAMS

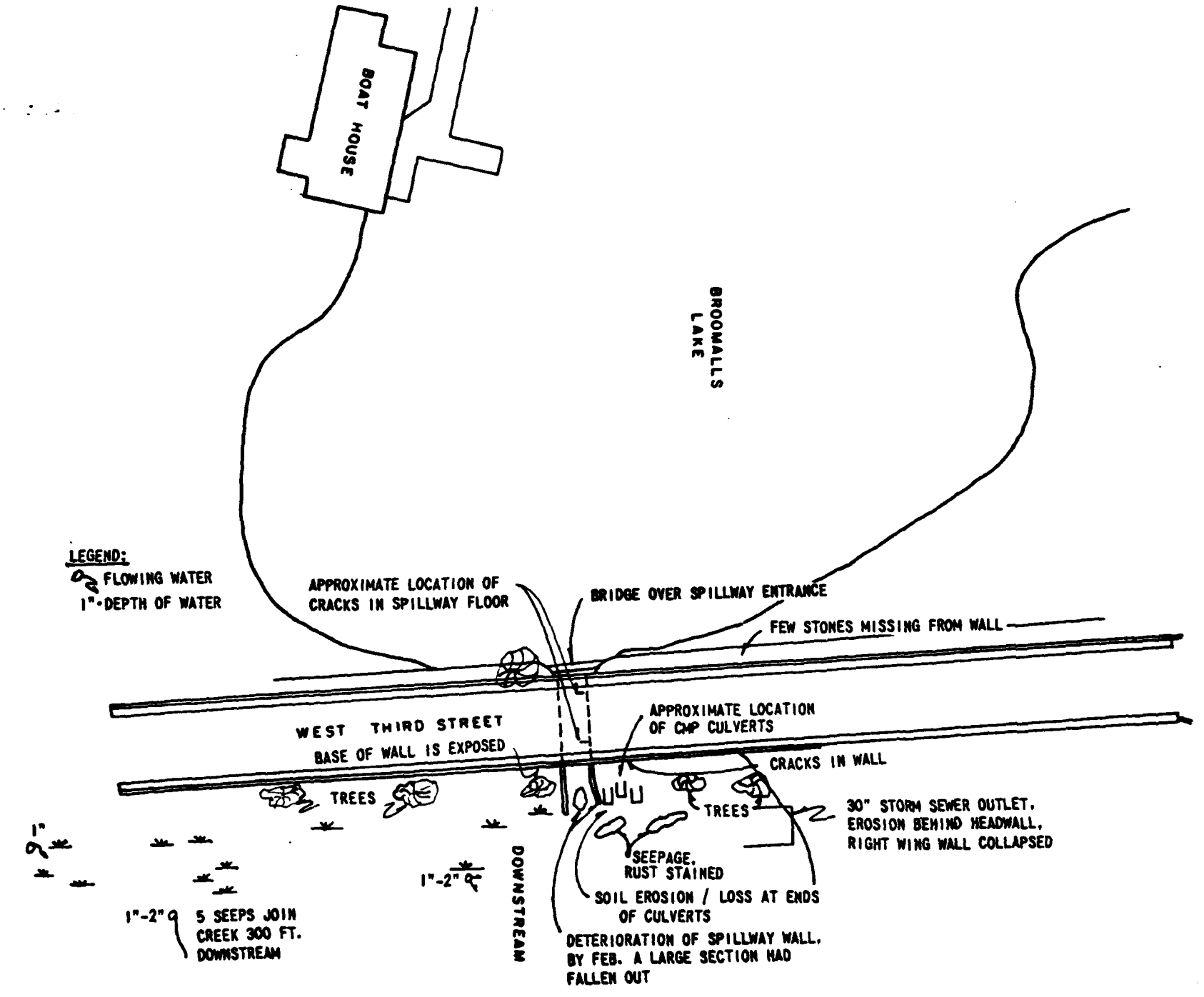
VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	N/A	
STRUCTURAL CRACKING	N/A	
VERTICAL AND HORIZONTAL ALIGNMENT	N/A	
MONOLITH JOINTS	N/A	
CONSTRUCTION JOINTS	N/A	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	*The left downstream wall has cracking between the wall and roadway pavement in spite of recent repairs. Reportedly, cracks were repaired recently between the upstream wall and pavement.*	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	*None observed.*	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	*The downstream slope has eroded, reportedly as a result of rain runoff from Third Street flowing over the downstream wall. Soil has been washed out from under the footing of the downstream wall at a point right of the spillway. Soil has been washed out from under the CMP conduits, see Photographs, Appendix D.*	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	*The downstream parapet wall appears to have moved downward.*	
RIPRAP FAILURES	*N/A, no riprap*	

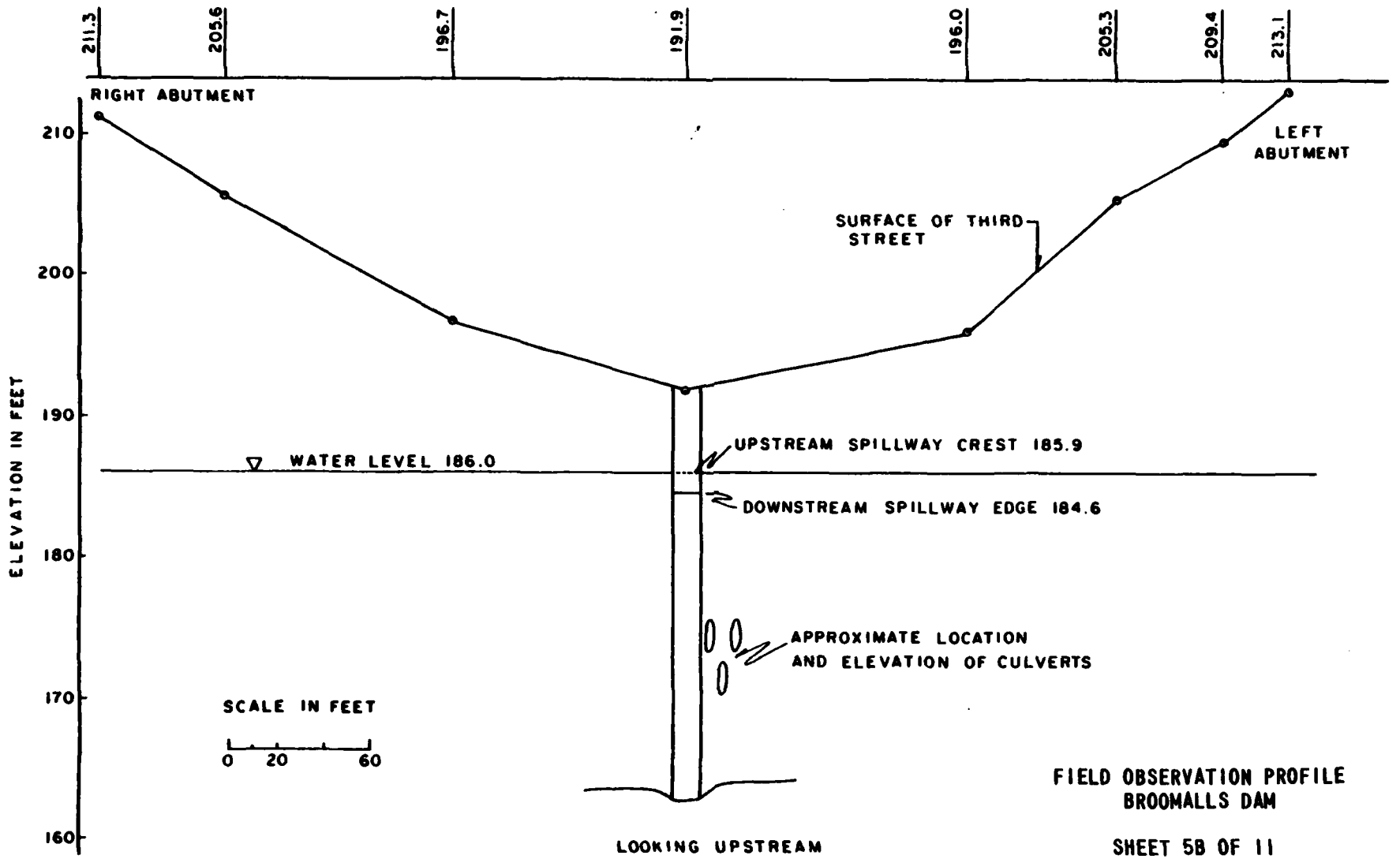
EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
UPSTREAM AND DOWNSTREAM MASONARY WALLS	*Cracking observed in downstream wall adjacent to spillway. Deterioration of mortar also noted. February 1980, large section of left downstream spillway wall had fallen out. Smaller section missing from right spillway wall.*	
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	*Erosion has occurred at the junction of the embankment and spillway and at the downstream junction of the embankment and left abutment aggravated by a storm sewer outlet.*	
ANY NOTICEABLE SEEPAGE	*Seepage noted about 30 and 60 feet to the right of the spillway, see Sheet 5a.*	
STAFF GAGE AND RECORDER	*None*	
DRAINS	*None located.*	



FIELD OBSERVATION PLAN
BROOMALLS DAM

SHEET 5A OF 11



FIELD OBSERVATION PROFILE
BROOMALLS DAM

SHEET 5B OF 11

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	*N/A, cast iron pipe and riveted seam pipe through dam.*	
INTAKE STRUCTURE	*Not observed, reportedly the upper pipe is sealed with a board held in place by water pressure. The intake for the lower pipe is probably buried in sediment.*	
OUTLET STRUCTURE	*N/A, both drains outlet through the spillway.*	
OUTLET CHANNEL	*N/A*	
EMERGENCY GATE	*The upper pipe is reportedly sealed with a board and no flow was observed through the pipe. The control valve for the lower pipe has not been located for at least 28 years nor reported operable for more than 65 years.*	

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	*The apron at the entrance to the spillway is about 20 years old and is in good condition. The three 43 x 2 inch "squashed" pipe arch culverts which supplement the spillway are set flush with upstream wall.*	
APPROACH CHANNEL	*N/A*	
DISCHARGE CHANNEL	*The channel immediately below the dam has much stone in it from the deterioration of the spillway, storm sewer outlet and, apparently, from collapsed channel walls.*	
BRIDGE AND PIERS	*N/A*	

GATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	*N/A*	
APPROACH CHANNEL	*N/A*	
DISCHARGE CHANNEL	*N/A*	
BRIDGE AND PIERS	*N/A*	
GATES AND OPERATION EQUIPMENT	*N/A*	

INSTRUMENTATION

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	*None*	
OBSERVATION WELLS	*None*	
WEIRS	*None*	
PIEZOMETERS	*None*	
OTHER	*None*	

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	*Part of the reservoir slope is steep and wooded to the water's edge. The rest of the reservoir slopes are moderate and partly vegetated and partly paved (parking lot) or swimming pools or tennis courts.*	
SEDIMENTATION	*Considerable sediment in channel above tennis courts (formerly a swamp) and in the pond. Sediment currently has litle or no effect on flood water storage.*	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	*Channel is fairly open with some logs across top of channel. The 14 foot wide channel with 1H:1V side slopes flows through wooded flood plain. Flood plain to right of channel has considerable underbrush.*	
SLOPES	*The valley gradient is about 0.02.*	
APPROXIMATE NO. OF HOMES AND POPULATION	*About 2000 feet below the dam are three houses that would be damaged in the event of a failure. These houses are reported to get water in the basements during periods of high runoff*	

APPENDIX

B

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM *Broomalls Lake Dam*

ID # *PA 00349*

ITEM	REMARKS
AS-BUILT DRAWINGS	*None, see Appendix E.*
REGIONAL VICINITY MAP	*Plate 1, Appendix E.*
CONSTRUCTION HISTORY	*See text.*
TYPICAL SECTIONS OF DAM	*Appendix E.*
OUTLETS - PLAN	*Appendix E.*
DETAILS	
CONSTRAINTS	
DISCHARGE RATINGS	*Appendix D.*
RAINFALL/RESERVOIR RECORDS	*None*

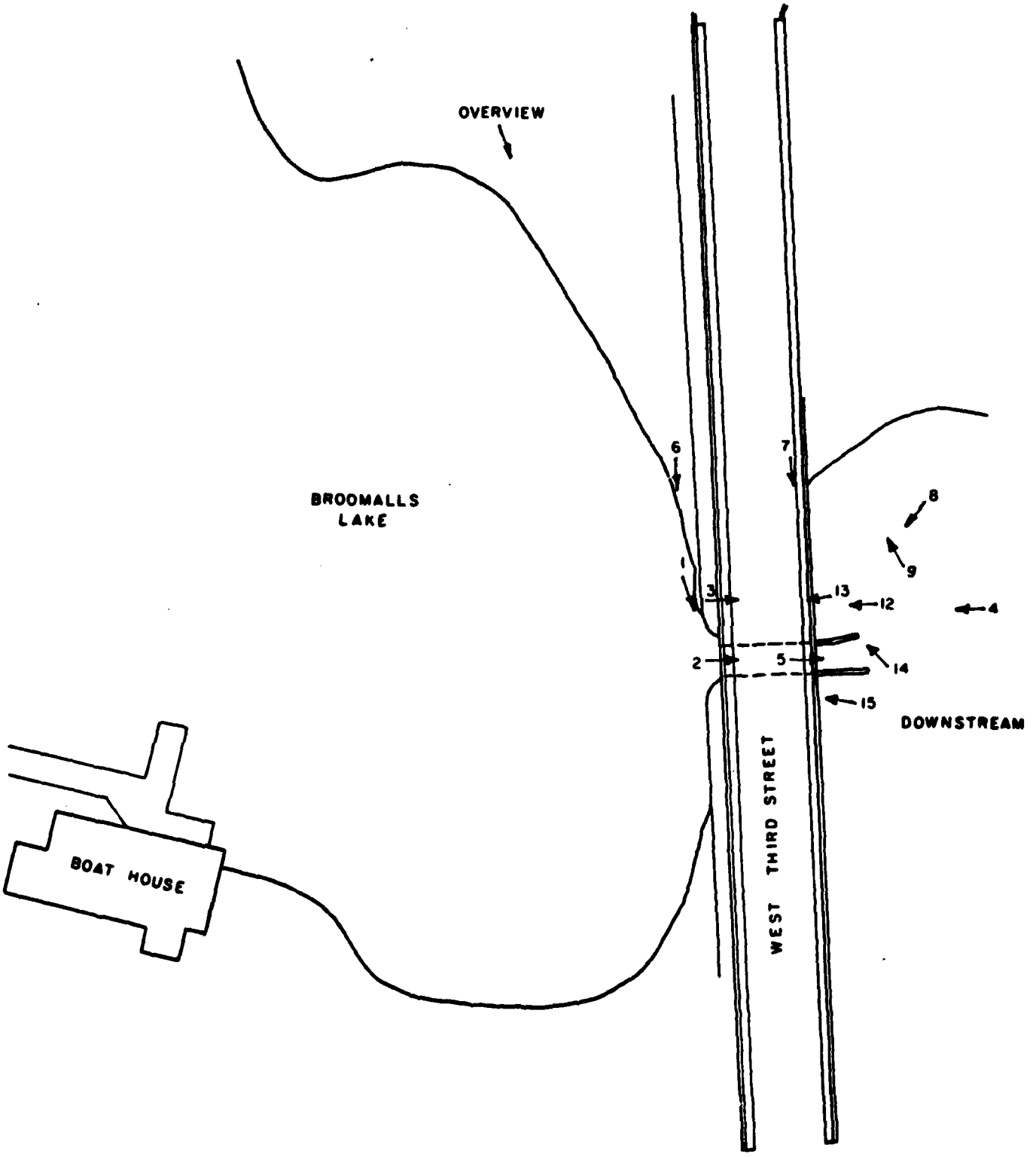
ITEM	REMARKS
DESIGN REPORTS	*None*
GEOLOGY REPORTS	*See Appendix F.*
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	*See text.*
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	*None*
POST-CONSTRUCTION SURVEYS OF DAM	*None known*
BORROW SOURCES	*Reportedly from adjacent hillsides.*

ITEM	REMARKS
MONITORING SYSTEMS	*None*
MODIFICATIONS	*Addition of 3-CMP culverts, and upstream and downstream parapet walls.*
HIGH POOL RECORDS	*None, high water estimated 4.8 feet above normal pool.*
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	*None known.*
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	*None known.*
MAINTENANCE OPERATION RECORDS	*None*

ITEM	REMARKS
SPILLWAY PLAN SECTIONS DETAILS	*Appendix E.*
OPERATING EQUIPMENT PLANS & DETAILS	*None available.*
MISCELLANEOUS	*1. State inspection reports.* *2. Corresondence between State and Owner.* *3. 13 black and white photographs.*

APPENDIX

C

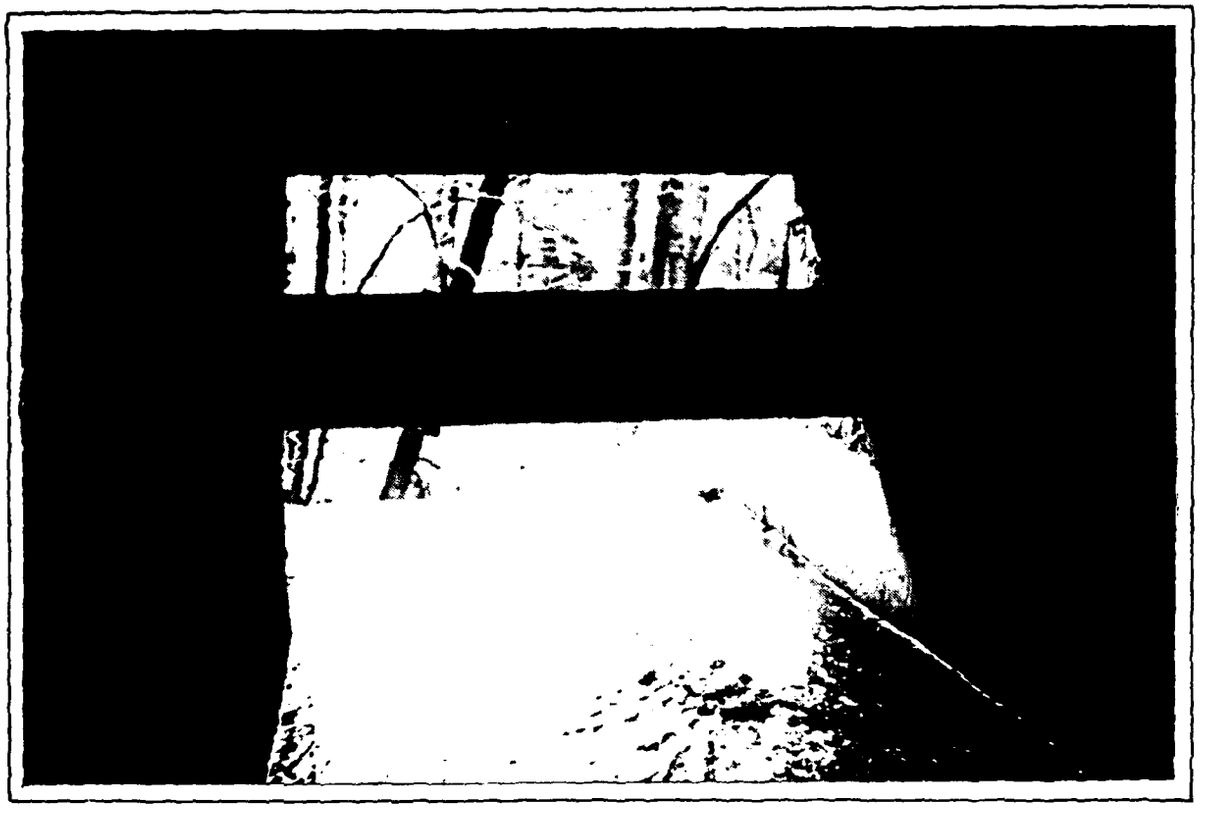


PHOTOGRAPH LOCATION PLAN
BROOMALLS DAM

PLATE C-1

UPSTREAM SIDE OF SPILLWAY.

PHOTOGRAPH NO. 1



VIEW OF SPILLWAY CHANNEL UNDER THIRD STREET. THE 12 INCH WATER LINE IS ENCLOSED IN A 18 INCH JACKET.

PHOTOGRAPH NO. 2

UPSTREAM SIDE OF CORRUGATED METAL CULVERTS.
THE THREE CULVERTS ARE TO THE LEFT OF THE
SPILLWAY SHOWN IN PHOTOGRAPH NO. 1.

PHOTOGRAPH NO. 3

UPSTREAM SIDE OF CORRUGATED METAL CULVERTS.
THE THREE CULVERTS ARE TO THE LEFT OF THE
SPILLWAY SHOWN IN PHOTOGRAPH NO. 1.

PHOTOGRAPH NO. 3

DOWNSTREAM SIDE OF SPILLWAY AND CULVERT.

PHOTOGRAPH NO. 4

VIEW OF DOWNSTREAM CHANNEL FROM
TOP OF DAM.

PHOTOGRAPH NO. 5

OVERALL VIEW OF UPSTREAM SIDE OF DAM.

PHOTOGRAPH NO. 6

OVERALL VIEW OF CREST. NOTE PAVEMENT REPAIR IN VICINITY OF CULVERTS AND DEFLECTION OF DOWNSTREAM WALL.

PHOTOGRAPH NO. 7

OVERALL VIEW OF DOWNSTREAM SIDE. NOTE LARGE TREES.

PHOTOGRAPH NO. 8

DETERIORATED STORM SEWER HEADWALL AT
LEFT ABUTMENT (DOWNSTREAM SIDE).

PHOTOGRAPH NO. 9

FIRST DOWNSTREAM DAMAGE CENTER. A SECOND HOUSE IS BEHIND THE TREE AT THE LEFT OF THE PICTURE.

PHOTOGRAPH NO. 10

60 INCH CULVERT UNDER RIDLEY CREEK ROAD, DOWNSTREAM OF DAMAGE CENTER.

PHOTOGRAPH NO. 11

DEFLECTION OF CULVERT OUTLETS.

PHOTOGRAPH NO. 12

CLOSE-UP OF EROSION UNDER
CENTER CULVERT OUTLET.

PHOTOGRAPH NO. 13

PHOTOGRAPH TAKEN IN MARCH.
SECTION OF SPILLWAY WALL HAS
FALLEN OUT. ICE REMANENT IN
CULVERT OUTLET.

PHOTOGRAPH NO. 14

CLOSE-UP OF SPILLWAY DETERIORATION.
PHOTOGRAPH TAKEN IN MARCH.

PHOTOGRAPH NO. 14A

EROSION UNDER THE DOWNSTREAM WALL TO
THE RIGHT OF SPILLWAY.

PHOTOGRAPH NO. 15

APPENDIX

D

BROOMALLS DAM
CHECK LIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: *Urban area, fully developed.*

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): *185.9 feet (18 Acre-Feet).*

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): *191.9 feet (41 Acre-Feet).*

ELEVATION MAXIMUM DESIGN POOL: --

ELEVATION TOP DAM: *191.9 feet.*

SPILLWAY

a. Elevation *185.9 feet*

b. Type *Box culvert with free overfall.*

c. Width *9 feet - 7 inches at entrance, 7 feet - 10 inches under road.*

d. Length

e. Location Spillover *Maximum section.*

f. Number and Type of Gates *None*

OUTLET WORKS:

a. Type *3 27" x 43" CMP pipe arch culverts.*

b. Location *Left of box culvert.*

c. Entrance inverts *186.3 feet.*

d. Exit inverts *Unknown, see photographs.*

e. Emergency draindown facilities *10 inch pipe about 2.5 below spillway.*
Non-functional drain at base of dam.

HYDROMETEOROLOGICAL GAGES:

a. Type *None*

b. Location *N/A*

c. Records *N/A*

MAXIMUM NON-DAMAGING DISCHARGE: *Not determined.*

BROOMALLS DAM

HYDROLOGIC AND HYDRAULIC
BASE DATA

DRAINAGE AREA:(1) *0.54 square mile.*

PROBABLE MAXIMUM PRECIPITATION (PMP)
FOR 10 SQ. MILES IN 24 HOURS:(2) *23.5 inches.*

ADJUSTMENT FACTORS FOR DRAINAGE AREA (%):(3)

Zone *6*

6 Hours *113%*

12 Hours *123%*

24 Hours *132%*

48 Hours *143%*

SNYDER HYDROGRAPH PARAMETERS:(4)

Zone *10*

C_p, C_t *0.60, 1.25*

L(5) *0.99*

Lca (6) *0.52*

$tp=C_t\ (L \cdot Lca)^{0.3}$ *1.02*

SPILLWAY CAPACITY AT MAXIMUM
WATER LEVEL(7) *539 cfs.*

---

(1) Measured from USGS maps.
(2) Hydrometerological Report No. 33, Figure 1.
(3) Hydrometerological Report No. 33, Figure 2.
(4) Information received from Corps of Engineers, Baltimore District.
(5) Length of longest water course from outlet to basin divide, measured from USGS maps.
(6) Length of water course from outlet to point opposite the centroid of drainage area, (see Plate 1, Appendix E) measured from USGS maps.
(7) See Sheet *12* of this Appendix.

HEC-1, REVISED
FLOOD HYDROGRAPH PACKAGE

The original "Flood Hydrograph Package" (HEC-1), developed by the Hydrologic Engineering Center, Corps of Engineers, has been modified for use under the National Dam Inspection Program. The "Flood Hydrograph Package (HEC-1), Dam Safety Version", hereinafter referred to as, HEC-1, Rev., has been modified to require less detailed input and to include a dam breach analysis. The required input is obtained from the field inspection of a dam, any available design/evaluation data, relatively simple hydraulic calculations, or information from the USGS Quandrangle maps. The input format is flexible in order to reflect any unique characteristics of an individual dam.

HEC-1, Rev. computes a reservoir inflow hydrograph based on individual watershed characteristics such as: area, percentage of impervious surface area, watershed shape, and hydrograph characteristics determined from regional correlation studies by the Corps of Engineers, Baltimore District. The inflow is routed through the reservoir using spillway discharge data obtained from the field inspection or design data. Flood storage capacity is determined from USGS maps or design information and verified by the field inspection. In the event a spillway cannot discharge 0.5 PMF without overtopping and failure of the dam, downstream channel characteristics obtained from the field inspection and USGS maps are inputed and flows are routed downstream to the damage center and a dam breach analysis is performed.

Included in this Appendix are the HEC-1, Rev. pertinent input values and a summary print-out tables.

MEB DATE 2/22/80 SUBJECT Broomalls Dam SHEET 4 OF 14

CKD. BY AHD DATE 2/29/80 Hydrology / Hydraulics JOB No.

Classification (Ref- Recommended Guidelines for Safety Inspection of Dams)

1. The hazard classification is rated a "High" as there would be excessive economic loss and the potential for loss of life in the event of failure.

2. The size classification is "Small" based on its 28 ft. height

3. The selected spillway design flood, based on size and hazard classification, is 0.5PMF (Probable Maximum Flood).

Hydrology and Hydraulic Analysis

1. Original Data. No original data exist. In 1915 the state estimated the spillway capacity to be greater than 400cfs and to be adequate.

2. Evaluation Data.
Inflow hydrograph parameters are shown on sheet 2.

Elevation- storage data shown on sheet 8. The computer calculated volume based on area measured from a contour plan of the reservoir based on soundings taken by the Owner.

Elevation-discharge data. At very low flows, the weir in front of the box culvert will control discharge. Otherwise, inlet control at both the box culvert and CMP culverts is assumed. Reference for inlet control - ___ - Soil Conservation Service, Nat. Eng. Handbook - 4.
The invert of the box culvert is 185.9, 5.3ft. high & 9.58ft. wide. The pipe-arch culvert invert is at 186.3.

	Box Culvert				Pipe-Arch				Weir	Total Q
W.S	HW	HW/D	Q/b	Q_{BC}	HW	HW/D	Q	3Q	$3.1 \cdot 9.58 H^{3/2}$	
185.9	0	0	0	0	0				0 ✗	0
187.1	1.2 ✓	.23 ✓			0.8 ✓	0.35 ✓	5 ✓	15 ✓	38 ✓	53 ✓
187.4	1.5 ✓	.28 ✓			1.1 ✓	0.49 ✓	10 ✓	30 ✓	55 ✓	85 ✓
188.1	2.2 ✓	.42 ✓	8.0 ✓	77 ✓	1.8 ✓	0.80 ✓	22 ✓	66 ✓		143 ✓
190.8	4.9 ✓	.92 ✓	26.0 ✓	249 ✓	4.5 ✓	2.0 ✓	55 ✓	165 ✓		414 ✓
193.0	7.1 ✓	1.34 ✓	46.0 ✓	441 ✓	6.7 ✓	3.0 ✓	75 ✓	225 ✓		666 ✓
195.3	9.4 ✓	1.77 ✓	60.0 ✓	575 ✓	9.0 ✓	4.0 ✓	90 ✓	270 ✓		845 ✓

BY MEB DATE 2/27/80 SUBJECT SHEET 5 OF 14

CHKD. BY AHD DATE 2/29/80 Broomalls Dam JOB No.

Hydraulics / Hydrology

3. Spillway Adequacy

As the spillway will not discharge the spillway design storm (0.5PMF) without overtopping the embankment, the spillway is considered "Inadequate". As the dam is assessed to fail by overtopping, and the potential for damaged is increased, the spillway is considered "Seriously Inadequate".

```
1**********
 FLOOD HYDROGRAPH PACKAGE (HEC-1)
 DAM SAFETY VERSION      JULY 1978
   LAST MODIFICATION  26 FEB 79
 **********

 RUN  DATE= 80/02/28.
      TIME= 13.31.16.
```

BROOMALLS LAKE DAM
NAT ID NO. PA 00349 DER NO. 23-9
OVERTOPPING ANALYSIS

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
150	0	15	0	0	0	0	0	-4	0
			JOPER	NUT	LROPT	TRACE			
			5	0	0	0			

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 5 LRTIO= 1

RTIOS= .10 .20 .30 .40 .50

SHEET 6 OF 14

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
IN	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	.54	0.00	.54	1.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	23.50	113.00	123.00	132.00	143.00	0.00	0.00

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.05	0.00	0.00

UNIT HYDROGRAPH DATA

TP= 1.02 CP= .60 NTA= 0

RECESSION DATA

STRTQ= -1.50 QRCSN= -.05 RTIOR= 2.00

UNIT HYDROGRAPH 23 END-OF-PERIOD ORDINATES, LAG= 1.01 HOURS, CP= .61 VOL= 1.00

22.	78.	147.	197.	205.	173.	133.	102.	78.	60.
46.	35.	27.	21.	16.	12.	9.	7.	6.	4.
3.	3.	2.							

0 END-OF-PERIOD FLOW

NO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	NO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
									SUM	33.61	31.14	2.47	43097.
										(854.)	(791.)	(63.)	(1220.37)

SHEET 7 OF 14

HYDROGRAPH ROUTING

OUTFLOW HYDROGRAPH

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
OUT	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-186.	-1

STAGE	185.90	187.10	187.40	187.90	188.10	188.30	188.60	190.80	193.00	195.30
FLOW	0.00	53.00	85.00	118.00	143.00	166.00	187.00	414.00	665.00	845.00
SURFACE AREA=	0.	1.	2.	2.	3.	4.	10.			
CAPACITY=	0.	1.	4.	7.	18.	32.	101.			
ELEVATION=	175.	177.	179.	181.	186.	190.	200.			

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
185.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
191.9	0.0	0.0	0.

CREST LENGTH AT OR BELOW ELEVATION	0. 191.9	105. 193.0	145. 194.0	175. 195.0	273. 200.0

SHEET 8 OF 14

HYDROGRAPH ROUTING

FIRST DOWNSTREAM SECTION

ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
DS1	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	0.	0

SHEET 9 OF 14

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.0600	.0400	.0650	150.0	164.0	1700.	.03300

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

0.00 171.50 51.00 160.30 87.00 154.70 91.00 150.00 105.00 150.00
109.00 154.00 184.00 155.60 208.00 164.00

STORAGE	0.00	.42	.88	1.38	1.92	2.50	3.28	5.00	7.77	10.90
	14.23	17.76	21.48	25.40	29.52	33.81	38.26	42.87	47.63	52.55
OUTFLOW	0.00	56.37	178.40	351.33	570.67	834.76	1164.89	1652.73	2399.60	3435.00
	4705.53	6203.42	7925.76	9872.20	12044.31	14462.90	17104.50	19969.64	23059.45	26375.53
STAGE	150.00	150.74	151.47	152.21	152.95	153.68	154.42	155.16	155.89	156.63
	157.37	158.11	158.84	159.58	160.32	161.05	161.79	162.53	163.26	164.00
FLOW	0.00	56.37	178.40	351.33	570.67	834.76	1164.89	1652.73	2399.60	3435.00
	4705.53	6203.42	7925.76	9872.20	12044.31	14462.90	17104.50	19969.64	23059.45	26375.53

HYDROGRAPH ROUTING

RIDLEY CREEK ROAD

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
RCR	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	0.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.0180	.0180	.0180	118.9	130.0	150.	.00100

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

0.00 130.00 50.00 128.00 135.00 123.70 216.00 121.40 330.00 118.90
440.00 122.30 500.00 127.00 550.00 130.00

STORAGE	0.00	.05	.18	.41	.73	1.14	1.63	2.18	2.79	3.45
	4.15	4.89	5.66	6.48	7.33	8.22	9.16	10.14	11.17	12.26
OUTFLOW	0.00	15.33	97.32	286.93	617.94	1129.73	1850.65	2842.74	4046.19	5627.15
	7493.35	9607.91	11975.05	14599.10	17482.46	20620.97	24028.90	27714.45	31697.57	35986.44
STAGE	118.90	119.48	120.07	120.65	121.24	121.82	122.41	122.99	123.57	124.16
	124.74	125.33	125.91	126.49	127.08	127.66	128.25	128.83	129.42	130.00
FLOW	0.00	15.33	97.32	286.93	617.94	1129.73	1850.65	2842.74	4046.19	5627.15
	7493.35	9607.91	11975.05	14599.10	17482.46	20620.97	24028.90	27714.45	31697.57	35986.44

SHEET 10 OF 14

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 .10	RATIO 2 .20	RATIO 3 .30	RATIO 4 .40	RATIO 5 .50
HYDROGRAPH AT	IN	.54 (1.40)	1	252. (7.14)(	504. 14.27)(	756. 21.41)(	1008. 28.54)(	1260. 35.68)(
ROUTED TO	OUT	.54 (1.40)	1	228. (6.46)(	449. 12.71)(	711. 20.12)(	999. 28.29)(	1259. 35.65)(
ROUTED TO	DS1	.54 (1.40)	1	228. (6.46)(	448. 12.68)(	711. 20.13)(	996. 28.21)(	1250. 35.38)(
ROUTED TO	RCR	.54 (1.40)	1	228. (6.45)(	448. 12.69)(	711. 20.13)(	994. 28.15)(	1251. 35.41)(

SUMMARY OF DAM SAFETY ANALYSIS

No Failure

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	185.90	185.90	191.90
STORAGE	18.	18.	41.
OUTFLOW	0.	0.	539.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.10	189.00	0.00	28.	228.	0.00	41.00	0.00
.20	191.11	0.00	37.	449.	0.00	41.00	0.00
.30	192.75	.85	46.	711.	1.75	41.00	0.00
.40	193.40	1.50	50.	999.	2.50	40.75	0.00
.50	193.80	1.90	52.	1259.	3.50	40.75	0.00

PLAN 1 STATION DS1

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.10	228.	151.7	41.00
.20	448.	152.5	41.25
.30	711.	153.3	41.00
.40	996.	154.0	40.75
.50	1250.	154.5	40.75

PLAN 1 STATION RCR

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.10	228.	120.5	41.00
.20	448.	120.9	41.25
.30	711.	121.3	41.00
.40	994.	121.7	40.75
.50	1251.	121.9	40.75

SHEET 12 OF 14

SUMMARY OF DAM SAFETY ANALYSIS

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	185.90	185.90	191.90
STORAGE	18.	18.	41.
OUTFLOW	0.	0.	539.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.10	188.75	0.00	27.	1225.	0.00	40.82	40.50
.20	188.77	0.00	27.	1222.	0.00	39.58	39.25
.30	188.87	0.00	27.	1261.	0.00	38.57	38.25
.40	188.89	0.00	28.	1298.	0.00	38.08	37.75
.50	188.95	0.00	28.	1340.	0.00	37.83	37.50

PLAN 1 STATION DS1

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.10	1060.	154.2	41.00
.20	1093.	154.3	39.75
.30	1123.	154.3	38.75
.40	1173.	154.4	38.25
.50	1265.	154.6	40.75

PLAN 1 STATION RCR

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.10	1107.	121.8	41.00
.20	1135.	121.8	39.75
.30	1168.	121.9	38.75
.40	1219.	121.9	38.25
.50	1271.	121.9	38.00

SHEET 13 OF 14

Failure by piping along CMP culverts

DAM BREACH DATA

BRWID	Z	ELBM	TFAIL	USEL	FAILEL
50.	1.00	175.00	.50	185.90	188.60

SUMMARY OF DAM SAFETY ANALYSIS

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	185.90	185.90	191.90
STORAGE	18.	18.	41.
OUTFLOW	0.	0.	539.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.10	189.00	0.00	28.	228.	0.00	41.00	0.00
.20	191.11	0.00	37.	449.	0.00	41.00	0.00
.30	192.75	.85	46.	711.	1.75	41.00	0.00
.40	193.17	1.27	48.	2488.	.63	40.73	40.50
.50	193.31	1.41	49.	2717.	.89	40.49	40.25

PLAN 1 STATION DS1

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.10	228.	151.7	41.00
.20	448.	152.5	41.25
.30	711.	153.3	41.00
.40	2109.	155.6	40.75
.50	2436.	155.9	40.75

PLAN 1 STATION RCR

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.10	228.	120.5	41.00
.20	448.	120.9	41.25
.30	711.	121.3	41.00
.40	2157.	122.6	41.00
.50	2493.	122.8	40.75

DAM BREACH DATA

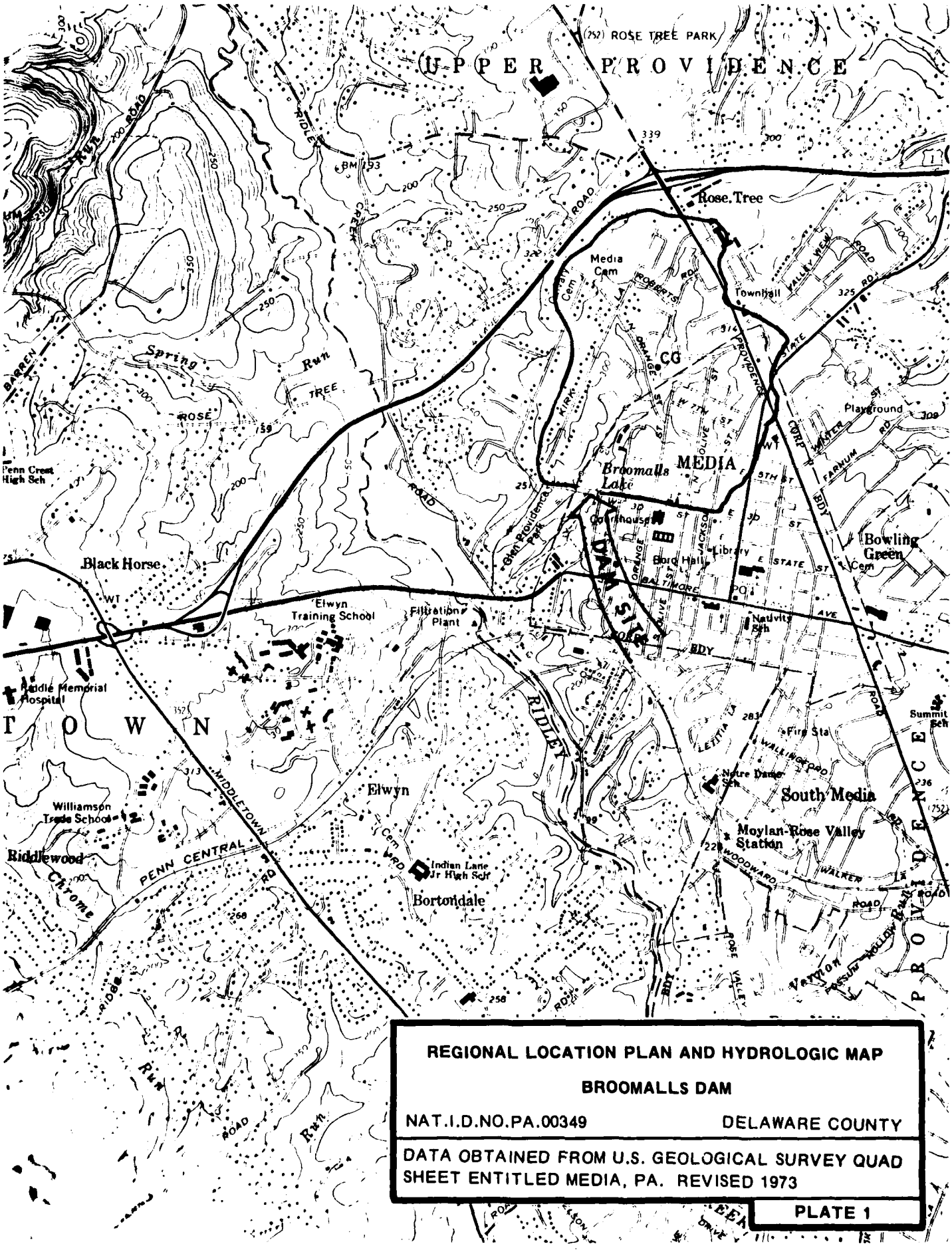
BRWID	Z	ELBM	TFAIL	WSEL	FAILEL
50.	1.00	175.00	.50	185.90	192.90

Failure by Overtopping

SHEET 14 OF 14

APPENDIX

E



REGIONAL LOCATION PLAN AND HYDROLOGIC MAP

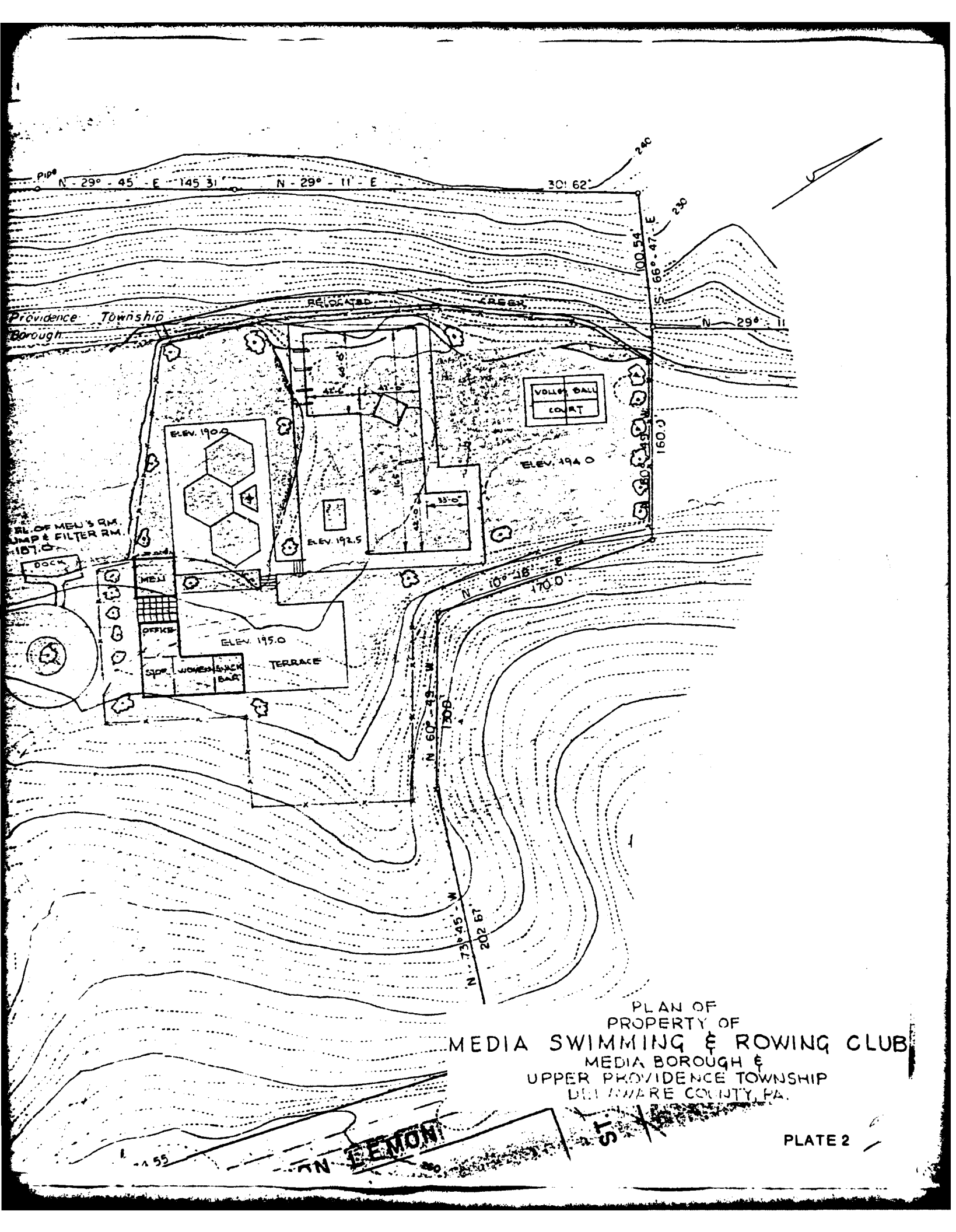
BROOMALLS DAM

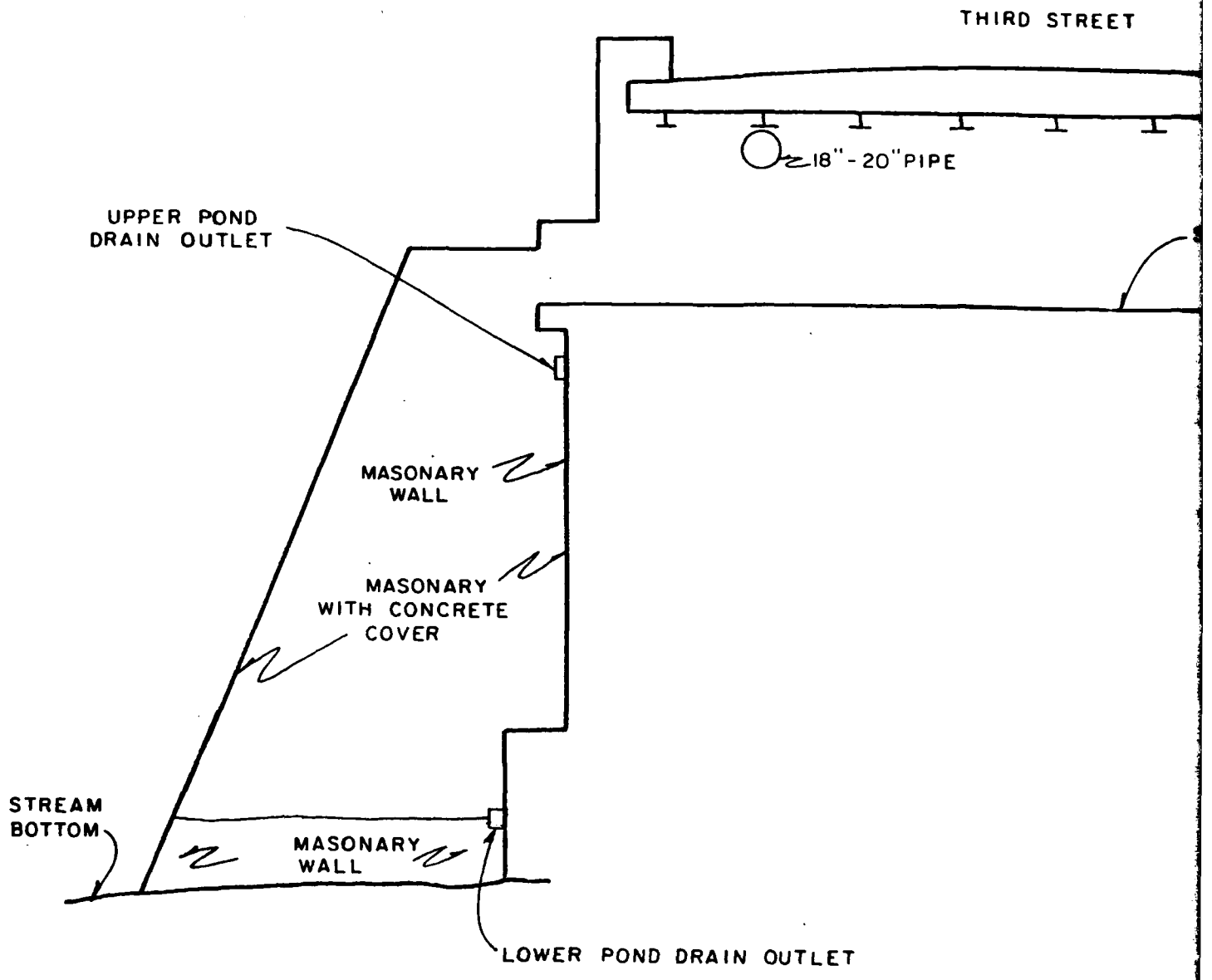
NAT.I.D.NO.PA.00349 DELAWARE COUNTY

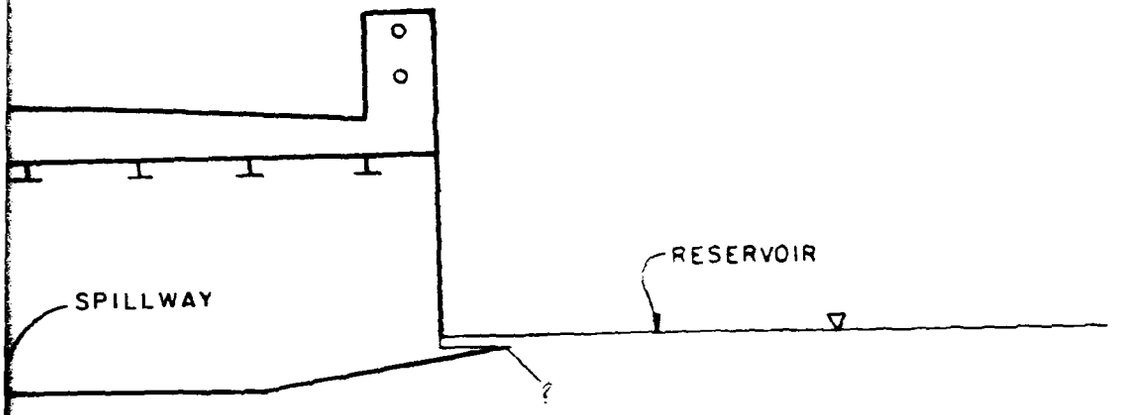
DATA OBTAINED FROM U.S. GEOLOGICAL SURVEY QUAD SHEET ENTITLED MEDIA, PA. REVISED 1973

PLATE 1


570.86
Pipe
Approx Township Line
Upper Providence
Media Borough
Boat House
LAKE
BROOMALLS
WATER ELEV. 185.9
DOCK
STREET
ELEV. 192.0
185.9
191.9
184.6
196.7
211.3
125.0
196
209.4
213.1
150.0
STREET
THIRD
145 CARS
PARCEL
230
190


PIPE
N - 29° - 45 - E 145.31'
N - 29° - 11' - E
30.62'
240
230
100.54'
S - 66° - 47 - E
RELOCATED CREEK
Providence Township
Borough
N - 29° - 11
VOLLEY BALL COURT
160.0'
ELEV. 190.0
ELEV. 194.0
ELEV. 192.5
EL OF MEN'S RM.
UMP & FILTER RM.
187.0
DOCK
MEN
OFFICE
ELEV. 195.0
SHOP
WOMEN
SNACK BAR
TERRACE
N - 10° - 18 - E
170.0'
N - 60° - 45 - W
160.8'
S - 45° - 23 - W
202.67'
N
PLAN OF
PROPERTY OF
MEDIA SWIMMING & ROWING CLUB
MEDIA BOROUGH &
UPPER PROVIDENCE TOWNSHIP
DELAWARE COUNTY, PA.
PLATE 2
LEMON
ST.


THIRD STREET
18" - 20" PIPE
UPPER POND
DRAIN OUTLET
MASONARY
WALL
MASONARY
WITH CONCRETE
COVER
STREAM
BOTTOM
MASONARY
WALL
LOWER POND DRAIN OUTLET



SCALE IN FEET

0 5

MAXIMUM SECTION
BROOMALLS DAM

PLATE 3

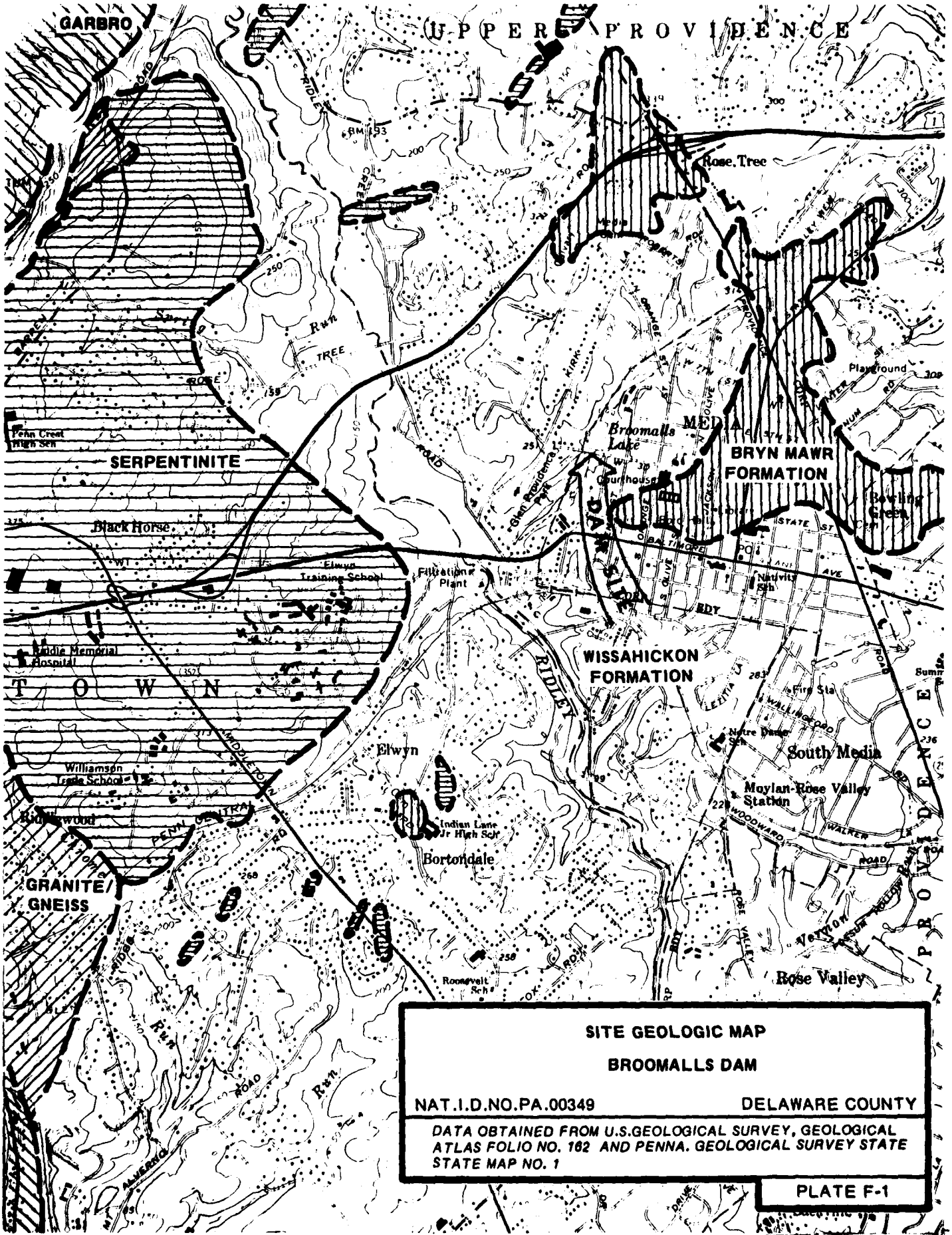
APPENDIX

F

SITE GEOLOGY
BROOMALLS LAKE DAM

Broomalls Lake Dam is located in the Piedmont Uplands Section of the Piedmont Physiographic Province. As shown in Plate F-1, the dam is underlain by the Wissahickon Formation of Lower Paleozoic age. Much of the bedrock in this region of Pennsylvania consists of igneous and metamorphic rocks, such as the schist of the Wissachickon Formation exposed in and around Media, Pennsylvania. Isolated deposits of Tertiary age sand and gravel occur in the area, such as the one which underlies much of Media.

An exposure of schist in the parking area next to the clubhouse has foliation, which strikes to the northeast (oblique to dam axis) and dips at a high angle to the southeast (downstream direction). This rock attitude could in part contribute to the formation of the seepage area observed along the toe of the right half of the dam.



SITE GEOLOGIC MAP

BROOMALLS DAM

NAT.I.D.NO.PA.00349 DELAWARE COUNTY

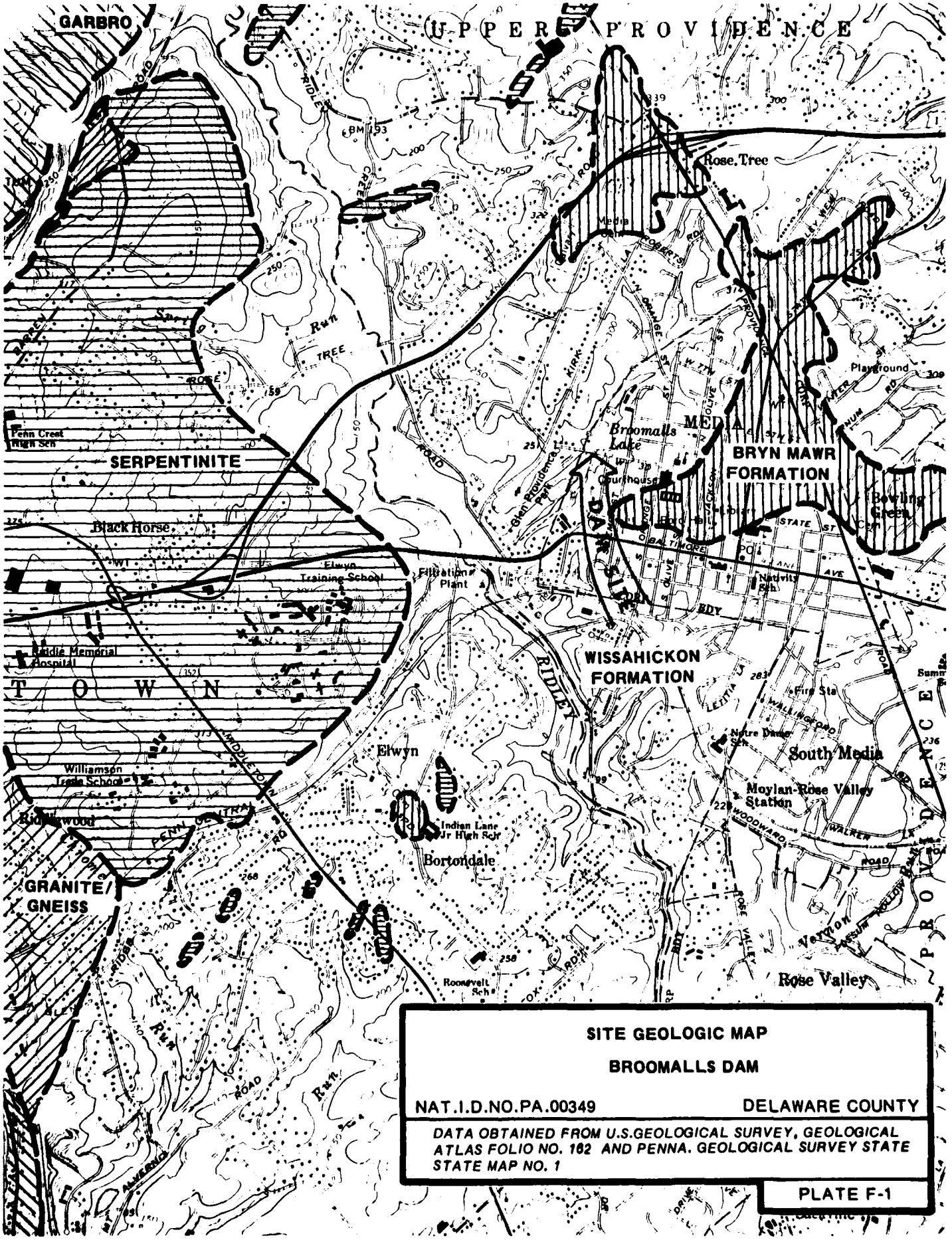
DATA OBTAINED FROM U.S.GEOLOGICAL SURVEY, GEOLOGICAL ATLAS FOLIO NO. 162 AND PENNA. GEOLOGICAL SURVEY STATE STATE MAP NO. 1

PLATE F-1

SITE GEOLOGY
BROOMALLS LAKE DAM

Broomalls Lake Dam is located in the Piedmont Uplands Section of the Piedmont Physiographic Province. As shown in Plate F-1, the dam is underlain by the Wissahickon Formation of Lower Paleozoic age. Much of the bedrock in this region of Pennsylvania consists of igneous and metamorphic rocks, such as the schist of the Wissachickon Formation exposed in and around Media, Pennsylvania. Isolated deposits of Tertiary age sand and gravel occur in the area, such as the one which underlies much of Media.

An exposure of schist in the parking area next to the clubhouse has foliation, which strikes to the northeast (oblique to dam axis) and dips at a high angle to the southeast (downstream direction). This rock attitude could in part contribute to the formation of the seepage area observed along the toe of the right half of the dam.


GARBRO
UPPER PROVIDENCE
Rose Tree
MEDIA
BRYN MAWR FORMATION
WISSAHICKON FORMATION
SERPENTINITE
GRANITE/ GNEISS
Broomalls Lake
Glen Providence Park
Penn Crest High Sch
Black Horse
Elwyn Training School
Filtration Plant
Riddle Memorial Hospital
T O W N
Williamson Trade School
Ridlewood
Elwyn
Indian Lane Jr High Sch
Bortondale
Roosevelt Sch
Nativity Sch
Bowling Green
Playground
Courthouse
Fire Sta
Notre Dame Sch
South Media
Moylan-Rose Valley Station
Rose Valley
PROVIDENCE
RIDLEY
ROSE TREE
RIDLEY CREEK
PENN CENTRAL
BROOMALLS DAM
NAT.I.D.NO.PA.00349
DELAWARE COUNTY
DATA OBTAINED FROM U.S.GEOLOGICAL SURVEY, GEOLOGICAL ATLAS FOLIO NO. 162 AND PENNA. GEOLOGICAL SURVEY STATE STATE MAP NO. 1
PLATE F-1